LA-UR-01-2864
Rev. 1
May 24, 2001

Environmental Technology Cost-Savings Analysis Project (ETCAP)

Requirements for Determination of the Light Duty Utility Arm (LDUA) Cost Savings

Scott DeMuth
Janet Harry
Ed Van Eeckhout
Victoria Sturgeon

General Distribution

Los Alamos
NATIONAL LABORATORY

Requirements for Determination of the Light Duty Utility Arm (LDUA) Cost Savings

May 24, 2001

Scott DeMuth
Janet Harry
Ed Van Eeckhout
Victoria Sturgeon

Decision Applications Division
Energy & Environmental Analysis Group
Los Alamos National Laboratory
Los Alamos, NM 87545

Abstract

In an effort to estimate cost savings due to the use of the Light Duty Utility Arm (LDUA) for retrieval and characterization of high level waste (HLW) from underground storage tanks (USTs), it was determined that the principal applications for the LDUA were essentially “enabling”. Estimating the cost savings due to the use of an enabling technology is difficult if not impossible due to the lack of a credible baseline. It was found by reviewing the literature that existing retrieval cost studies used either unrealistic baselines such as manned entry of HLW tanks, or baselines which could not achieve adequate waste removal such as past-practice sluicing. Consequently, this study was refocused to develop a methodology for establishing a credible baseline for cost comparison with the LDUA.

Acknowledgements

Funding for this study has been provided by the U.S. Department of Energy, Office of Science and Technology (EM-54).

Table of Contents

Introduction

As part of their Fiscal Year (FY) 2000 work scope, the Environmental Technology and Cost-Savings Analysis Project (ETCAP) agreed to evaluate the cost savings for the Light Duty Utility Arm (LDUA) used for characterization and retrieval of high-level waste (HLW) tanks across the Department of Energy (DOE) complex. In planning for their FY 2000, ETCAP solicited suggestions from the relevant DOE Office of Science and Technology (OST) Focus Areas for their work scope. The Tank Focus Area provided the suggestion that the LDUA development effort could benefit from a thorough cost savings analysis. Consequently, ETCAP took up the cause and has provided the following report as a summary of their LDUA related costs savings analysis. It was through the execution of this study that it became apparent why a complete and indisputable LDUA cost savings analysis had not yet been achieved. Furthermore, it became apparent that a complete study was beyond the scope of the effort anticipated for FY 2000 ETCAP activities. As a result, the following report summarizes the current state of cost related information applicable to the LDUA and proposes detailed efforts for completing the analysis in the future.

Summary

Originally this study was initiated in order to determine potential cost savings due to the use of the Light Duty Utility Arm (LDUA) for retrieval of waste from underground storage tanks across the U.S. Department of Energy (DOE) complex. As the effort progressed it was concluded that most of the relevant applications for the LDUA were essentially "enabling", such that other methods did not exist. As an example, the LDUA coupled with the confined sluicing end effector (CSEE) has the potential to achieve a degree of waste removal beyond existing technologies. However, the Innovative Technology Summary Report (ITSR) cost study for the CSEE (see Confined Sluicing End Effector ITSR) compared past-practice sluicing as the baseline, which cannot remove hard heels as the CSEE can. In fact, the only significant cost study completed to date for retrieval of waste too difficult for existing technologies used manned entry into the tank as the baseline (see Houdini™-II ITSR). While this approach does allow estimation of the cost savings based on a well-defined baseline, it is unlikely manned entry into HLW tanks will be allowed in today's regulatory climate. Consequently, it was decided to develop an approach for establishing a baseline where the waste would be left in-tank followed by the necessary immobilization and regulatory approval .

Characterization and Retrieval Market

The HLW tank characterization and retrieval market can initially be defined as all those located at the Hanford site, Savannah River site (SRS), Idaho Falls site, and Oak Ridge site as shown in Table 1. However, application of the LDUA is not possible for many of the tanks listed in Table 1, and thus can be eliminated. First, it is necessary to know if the retrieval required is gross or final for closure. Second, it is necessary to know the type of hardware obstructions in the tank and the type of access opening. And third, it is necessary to know the type of waste.

Table 1. Characterization and Retrieval Market

Hanford		**SRS**		**Idaho Falls**		**Oak Ridge**	
28 DSTs C.S.	1 Mgal	31 DSTs C.S.	1 Mgal	11 SSTs S.S.	0.3 Mgal	33 inactive GAATs	variable sizes
	alkaline waste		alkaline waste		acidic waste		mostly alkaline
149 SSTs C.S.	1 Mgal	8 SSTs C.S.	1 Mgal			13 active MVSTs	misc
	alkaline waste		alkaline waste				alkaline
		12 misc	misc				
			alkaline waste				

C.S. – carbon steel
S.S. – stainless steel

With most tanks the initial waste to be retrieved is more easily removed than the final as shown by Figure 1. In fact, the retrieval difficulty can be broadly divided into two categories, (1) gross removal of the initial waste and (2) final removal of the waste required to satisfy closure requirements. The following section "Characterization and Retrieval Technologies" will describe technologies available for both retrieval categories.

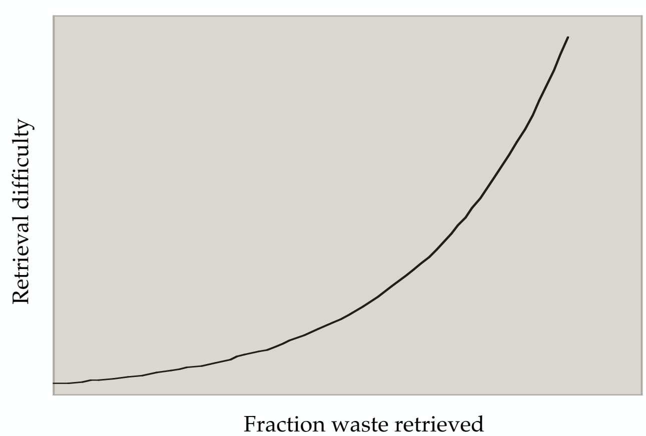

Figure 1. Waste retrieval difficulty

For gross or final retrieval the internal tank hardware and tank access ports will dictate the type of retrieval equipment used. Significant internal hardware and limited access ports will limit the potential retrieval equipment. In fact, personnel at Hanford have concluded that due to internal hardware complexity, combined with limited access ports, the LDUA or modified LDUA

(MLDUA) would have very limited if any applicability at their site. The other sites have not made similar conclusions so that each tank would need to be reviewed for these complications.

Waste type is important because it is essentially the final retrieval of hard heels that creates the market for the LDUA. Tanks that consist entirely of supernate would of course be retrievable with gross retrieval equipment. Tanks that consist of acidic waste rather than alkaline waste are less likely to form sludge and consequent hard heels, making them candidates for gross retrieval only. Based on the previous discussions it is clear that each candidate tank would need a careful evaluation to determine if it is a suitable candidate for LDUA characterization and/or retrieval. While tanks do share common designs at a given site they do not necessarily share common waste. Table 2 lists the individual Site (except Idaho Falls) characterization and retrieval needs as documented in the Tanks Focus Area Site Needs Assessment for FY2000. http://www.pnl.gov/tfa/program/needs00/index.stm

Table 2. Individual site needs

	Characterization	**Retrieval**
SRS	(1) In-situ waste tank corrosion probe (2) In-situ waste characterization	(1) Alternate waste removal technology (2) Advanced mixing technology (3) Heel removal/closure technology
ORO	(1) tank waste characterization	(1) Tank closure (2) Sludge mixing & mobilization (3) Solid waste retrieval
Hanford	(1) Sampling & analysis for operations & disposal (2) Remote inspection of HLW SSTs (3) DST integrity NDE measurement tools (4) TSAFT for knuckle region of DSTs (5) DST corrosion monitor (6) Radionuclide source term from tank residuals	(1) Establish retrieval performance evaluation criteria (2) Better waste mixing mobilization (3) SST salt cake dissolution & retrieval (4) Past practice sluicing improvement

Characterization and Retrieval Technologies

Figure 2 lists the baseline and innovative technologies that can be used for tank characterization and retrieval. In addition, Figure 2 lists the Innovative Technology Summary Report (ITSR) based value of cost savings for the innovative technologies with an existing ITSR. Generally speaking, the ITSRs have compared innovative technologies with baseline technologies adequate for only gross retrieval rather than final retrieval. When considering final retrieval, which can cost significantly more than gross retrieval, a realistic baseline does not exist with which to compare the "enabling" innovative technology. The LDUA falls into the category of final retrieval applicability, and in the case where a cost study exists (#812 - Confined Sluicing End Effector), it is unlikely the past-practice sluicing baseline can achieve final retrieval. In the case of technology #2095 – Houdini, also to be used for final retrieval, the baseline was manned entry which is not realistic.

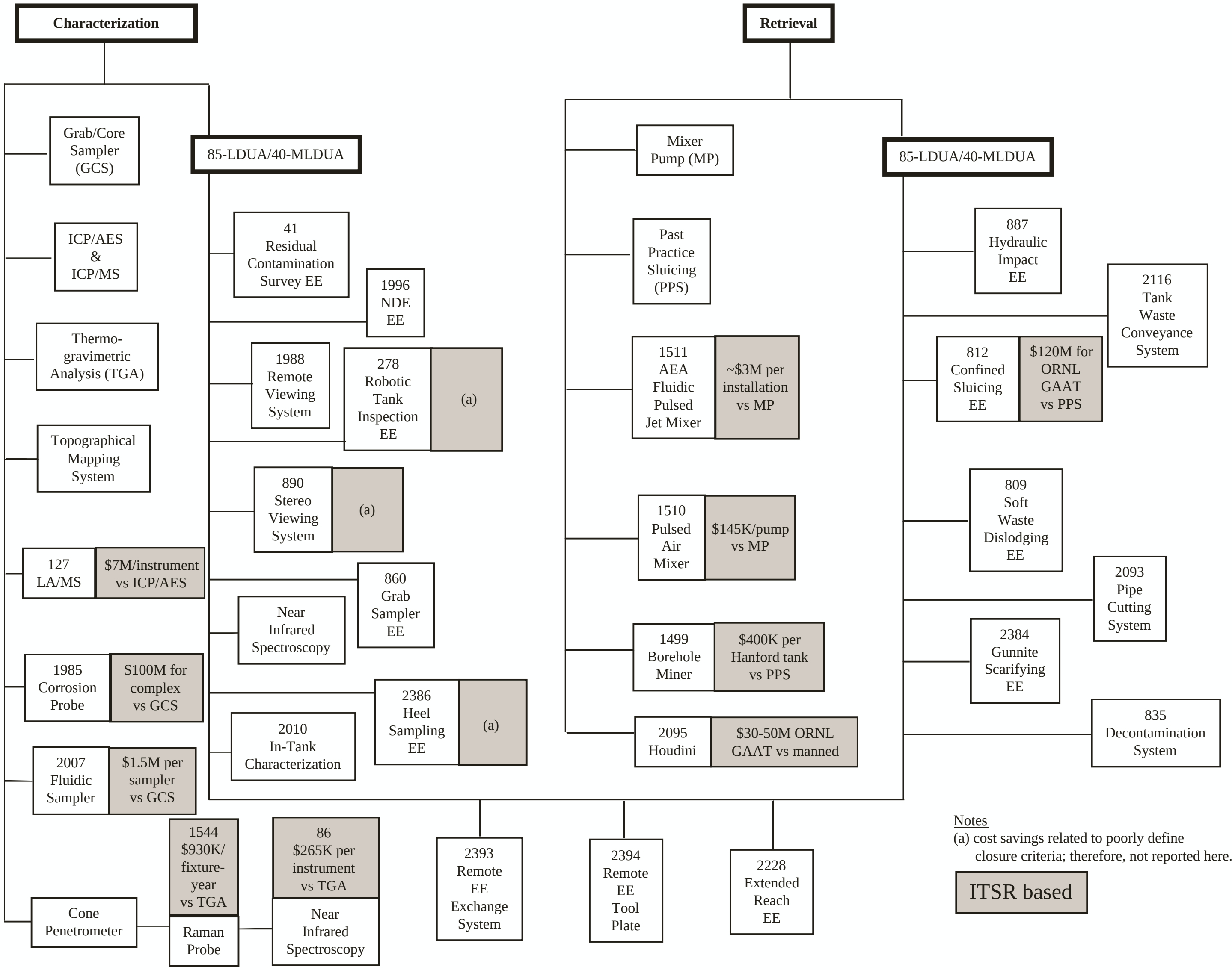

Figure 2. Tank characterization and retrieval technologies

Closure Technologies

Actual tank closures have been accomplished at Savannah River by utilizing steps 1, 2 and 3 shown in Figure 3 (SRS Tank Closure) and at Oak Ridge (ORNL/TM-2000/8). In the Savannah River case all closure activities occurred within the tank. However, in more troublesome cases it may be necessary to minimize the affect of rain water by way of a top cap, or minimize potential migration from within the tank by way of an underground barrier, as shown by Figure 3. If leaving waste in a tank is to be used as a baseline for comparison with LDUA enabling technologies such as the CSEE, it will be necessary to estimate the amount of hard heels remaining and its associated activity. This information could then be used to (1) determine the type of immobilization required and (2) estimate the additional effort required for closure regulatory approval.

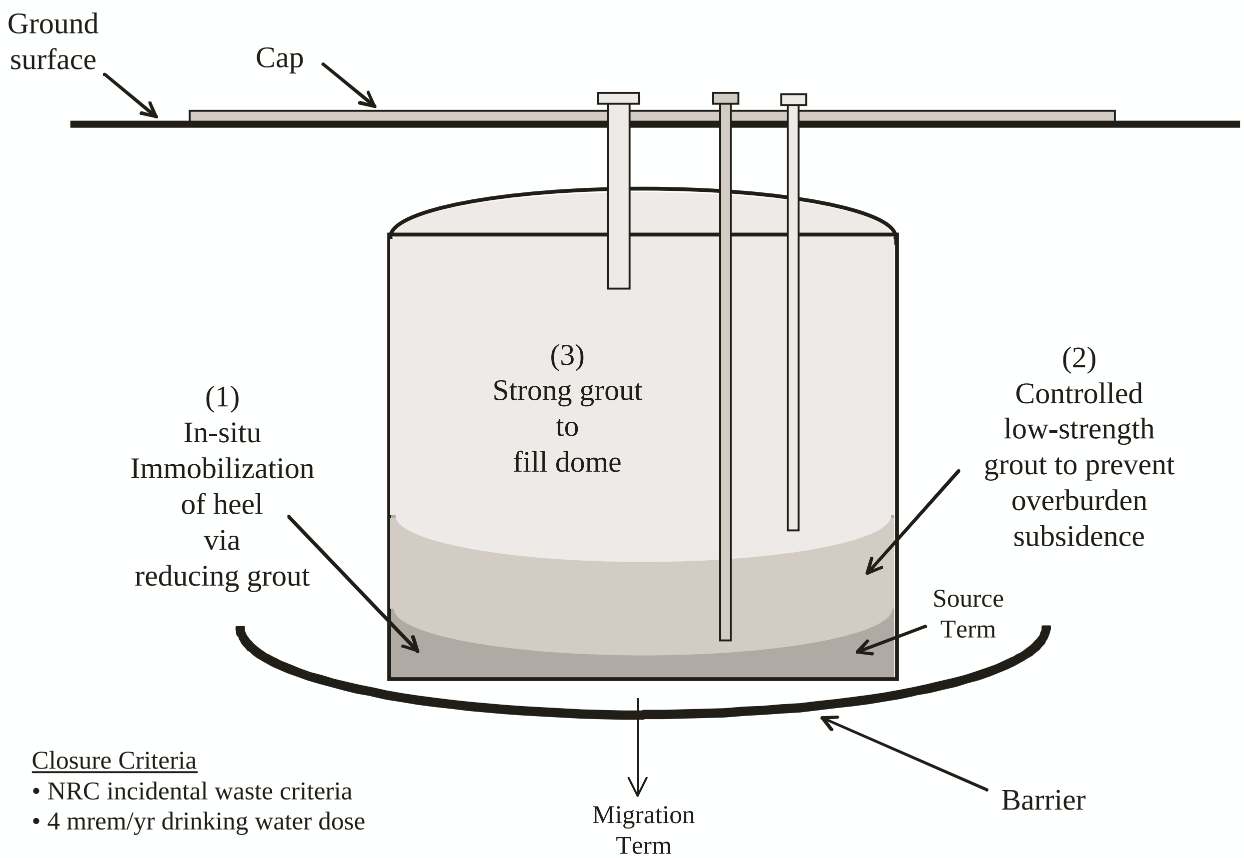

Figure 3. HLW tank closeout

Characterization and Retrieval Development Status

Table 3 summarizes the development status of (1) Gross characterization and retrieval technologies and (2) Final characterization and retrieval technologies. In each case it was assumed some degree of characterization of the waste and tank is required prior to retrieval. This status can be summarized as follows.

Gross Characterization and Retrieval

Gross characterization and retrieval is used for waste which can be retrieved with existing technologies. Baseline gross retrieval technologies include mixer pumps and past practice sluicing, such that characterization and retrieval cost estimates should be possible for most of the existing DOE tanks. Innovative gross retrieval technologies include the AEA Fluidic Pulsed Jet Mixer and Pulsed Air Mixer. Characterization and retrieval cost estimates for innovative gross retrieval technologies should be possible for most of the existing DOE tanks, and in fact do exist for selected tanks (DOE/EM-0447 & DOE/EM-0462).

Final Characterization and Retrieval

Final characterization and retrieval is for waste that remains after "gross characterization and retrieval". Final characterization and retrieval is further complicated by the complexity of the waste and the tank. Waste complexity relates to such things as its viscosity and activity; while tank complexity relates to access ports, internal structures, and tank integrity. Closeout costs for baseline final retrieval technologies for simple tanks and simple waste have been estimated for two SRS tanks (DOE/EM-0449) and four Hanford SSTs (HNF-2693). The Hanford study depends on the degree of heel removal ranging from 36-3600 ft^3 remaining. Closeout costs for baseline final retrieval technologies for complex waste and complex tanks have been estimated assuming manned entry of tanks, although it is doubtful regulatory approval could be obtained for this technique.

Closeout costs for innovative final retrieval technologies for simple tanks and simple waste have not been estimated. However, since the degree of waste removal for closeout was determined for the baseline cases of two SRS tanks and four Hanford SSTs, it is likely similar estimates for innovative technologies should be possible by comparison. Closeout costs for innovative final retrieval technologies for complex waste and complex tanks have not been estimated. In order to pursue such cost estimates a rational, albeit difficult, approach would be to compare the cost of each additional ft^3 of waste retrieved, with the reduction in in-tank immobilization and regulatory costs. At a minimum, it is these regulatory costs that currently are not well defined but have been studied (SAND98-2104).

Table 3. Characterization and Retrieval Development Status

<table>
<tr><th colspan="2" rowspan="2">Gross Characterization and Retrieval</th><th colspan="4">Final Characterization and Retrieval</th></tr>
<tr><th colspan="2">Simple tanks & waste</th><th colspan="2">Complex tanks & waste</th></tr>
<tr><th>Baseline</th><th>Innovative</th><th>Baseline</th><th>Innovative</th><th>Baseline</th><th>Innovative</th></tr>
<tr><td rowspan="3">Cost estimates possible for most DOE tanks</td><td>Cost estimates possible for most DOE tanks</td><td>Cost estimate available for 2-SRS tanks</td><td>Cost estimate possible for 2-SRS tanks</td><td rowspan="3">Cost estimate available for manned in-tank operations but manned in-tank operations would face significant regulatory hurdles</td><td rowspan="3">Cost estimate is available for MLDUA use in Gunite tanks at ORNL however baseline is manned in-tank operation</td></tr>
<tr><td rowspan="2">LDUA technology not competitive</td><td rowspan="2">Cost estimate available for 4-Hanford SSTs at 36-3600 ft^3 remaining heel</td><td>Cost estimate possible for 4-Hanford SSTs at 36-3600 ft^3 remaining heel but Hanford does not wish to use LDUA technology due to design of tanks</td></tr>
<tr><td>Cost estimate available for LDUA-CSEE versus past practice sluicing</td></tr>
</table>

Requirements for Determination of the Light Duty Utility Arm (LDUA) Cost Savings

The intent of this section is to suggest an approach and the related requirements for estimating LDUA cost savings, but not the only approach, or even the best approach. The best approach, as in beauty, is in the eye of the beholder. What is suggested here is to assume a model for closeout with various requirements depending on the degree of heel retrieval, such as that shown in Figure 3, and estimate the total cost including those related to regulatory efforts. Table 4 demonstrates how this can be done.

Table 4. Procedures required for tank closure

		Waste Removal		
		99.9%	99%	95%
Figure 3 Procedures	Steps 1,2 & 3	x	x	x
	Surface Cap		x	x
	Underground Barrier			x

It is clear from Table 4 that different levels of regulatory approval would be required for different degrees of waste removal. In fact, it is the determination of the regulatory needs that would likely comprise the major effort in such a study.

Conclusions and Recommendations

An approach has been suggested for determining cost savings for the use of the Light Duty Utility Arm (LDUA) for characterization and retrieval of HLW from underground storage tanks. However, because this approach is based upon estimating regulatory costs, and the regulatory effort itself has yet to be defined, actual cost estimation is reserved for future activities. Therefore, the suggested approach requires the following two efforts. First, the cost of using the LDUA for characterization and retrieval of final waste leading to tank closure must be estimated. Second, the cost of immobilization and regulatory efforts if the LDUA is not available, and waste that cannot be retrieved with existing technologies is left in the tanks. Following the completion of these two efforts the determination of LDUA cost savings should be relatively straight forward.

References

AEA Fluidic Pulse Jet Mixer, Innovative Technology Summary Report, DOE/EM-0447, U.S. Dept. of Energy, August 1999.

Confined Sluicing End Effector, Innovative Technology Summary Report, DOE/EM-0372, U.S. Dept. of Energy, September 1998.

S.A. Krieg, *AX Tank Farm Waste Retrieval Alternatives Cost Estimate,* HNF-2693, NUMATEC, Hanford, WA, Jul7 1998.

HoudiniTM-II Remotely Operated Vehicle System, Innovative Technology Summary Report, DOE/EM-0495, U.S. Dept. of Energy, December 1999.

Pulsed Air Mixer, Innovative Technology Summary Report, DOE/EM-0462, U.S. Dept. of Energy, August 1999.

J.R. Cochran and Lih-Jenn Shyr, *Regulatory Closure Options for the Residue in the Hanford Site Single-Shell Tanks*, SAND98-2104, Sandia National Laboratory, Albuquerque, NM, September 1998.

SRS Tank Closure, Innovative Technology Summary Report, DOE/EM-0449, U.S. Dept. of Energy, August 1999.

J.L Kauschinger and B.E. Lewis, *Utilization of the MPI™ Process for In-Tank Solidification of Heel Material in Large Diameter Cylindrical Tanks*, ORNL/TM-2000/8, Oak Ridge National Laboratory, Oak Ridge, TN, January 2000.

LDUA Internet Bibliography

http://em-52.em.doe.gov/ifd/techcards2/tanks/ldua.htm (uses at each site)

www.pnl.gov/WEBTECH/ustid/intank.html (report on baseline technologies)

www.pnl.gov/WEBTECH/ustid/lduasys.html (contract with Spar Aerospace)

www.pnl.gov/WEBTECH/ustid/lduadeco.html (description of decontamination system)

www.pnl.gov/tfa/tech/retr/cseefnl.htm (Schilling Titan II arm mounted on a remote vehicle such as the Houdini)

www.pnl.gov/tfa/back/abstracts/cooling.htm (cooling coil end effector)

www.pnl.gov/WEBTECH/ustid/ldualas.html (laser range finder end-effector)

www.cmst.org/cmst/Cmst-Cp_Reports/Feb97/MC30363.html (robotic tank end effector)

www.inel.gov/environment/stcg/archive/01-06-98.html (uses for Idaho)

http://em-52.em.doe.gov/ifd/tanks/pubs-brochures/ldua.gif (AC Field Measurement EE, water jet scarifier & TFA photo library of LDUA)

www.inel.gov/capabilities/robotics/UST/lduapic/INEL%20LDUA.JPG (color diagram from slides)

http://iridium.nttc.edu/env/USTID/USTID_chap1.html (major subsystems of LDUAS)

www.wpi.org/initiatives/init/fall98/spotlite.htm (cooperation of various orgs)

www.chornobyl.org/exchange/ldua.htm (3D goggles and camaras)

www.pnl.gov/tfa/tech/retr/ldua.html (leakage of C106-T)

www.pnl.gov/tfa/program/fy99techresp/98067a.pdf (need for tank analysis techniques)

www.wpi.org/initiatives/init/jun97/fluid.htm (disadvantages of dip sampling)

http://em-50.em.doe.gov/ifd/tfa/itsrs/itsr85/itsr85.pdf (current users: Hanford, ORNL)